

An Evaluation of a Graphical History Tool with an Eye Tracker

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Abstract. In this paper we describe a graphical undo/redo tool, which visualizes user's command history and evaluate it using a survey technique and empirically assess with respect to eye movements. Our tool is implemented as part of a drawing tool, what and how users look at are the essential information on evaluating its effectiveness. Therefore, we investigate user's gaze information during a visual searching task. The task is to search a target snapshot through looking at a window and manipulating its scroll bar. We have presented the first results of empirical evaluation's data. The results of primary evaluation show that the tool for visual search has been positive.

1. INTRODUCTION

Computer users make mistakes. This is common knowledge for all the HCI researchers and practitioners. Thus, most computer applications provide undo/redo function for their users. A typical Windows application, for example, has the undo/redo item under the edit item on the main menu bar. Including this Windows example conventional undo/redo functions are script-based. They require many commands (i.e., a series of undo/redo menu selections) to set the right state its user wants. We assume that users could get to the previous right state if they would have a graphical command history as a function of a system such as a drawing tool. To be precise, if user's command history is visible and listed as selection items, then the user could select the previous right state directly.

We have already proposed the double selective Undo model [Zhou 97] and presented a graphical command history tool [Meng 98]. The model and the tool are implemented by using Amulet system [Myers 97] together with a simple drawing editor. However, its evaluation was not yet conducted.

In this paper we illustrate the graphical command history tool and evaluate it using a survey technique. Since it is implemented as part of a drawing tool, what and how users watch are the essential information on evaluating its effectiveness. Therefore, we investigate user's gaze information during a visual searching task.

The rest of paper is organized as follows. We first review Undo/Redo models, then present the features of graphical history tool and evaluation of the tool by conducting controlled experiments.

2. UNDO MODELS AND A GRAPHICAL HISTORY TOOL

Undo models can be divided into two broad categories. One is Linear Undo, the other None Linear Undo. Most of the Undo mechanisms employed in today's graphical user interface systems are based on Linear Undo model. Recently, the Direct Selective Undo/Redo model was proposed [Berlage 94], and it allows the user to undo the command selectively from the history list.

We have proposed a graphical history tool [Meng 98](See Figure 1). The history visualization and grouping functions are implemented on Amulet system [Myers 97], developed by Carnegie Mellon University. The source codes are written in Microsoft Visual

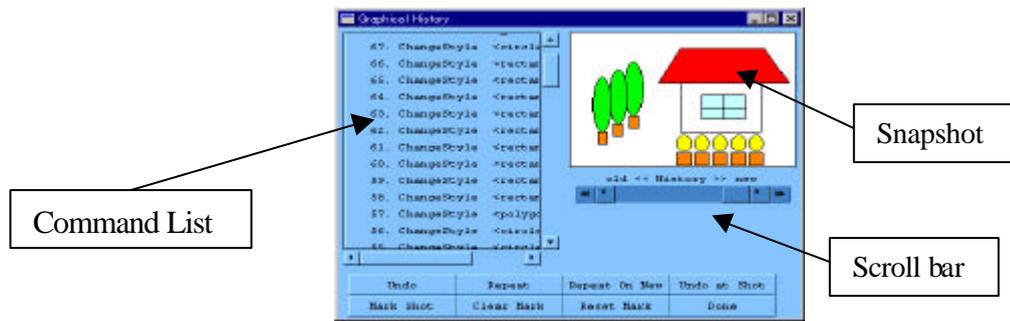


Figure 1. A Dialog box for the Selective Undo/Reuse

C++ on Windows NT.

There are two main features on the graphical history tool.

[1] Graphical history window: Considering that every change of the graphical editor window resembles an instance within a single continuum of visual history, we developed a visualized history view to this mechanism, listing “history snapshots” –the results to each command– to be presented as the command. Commands can be searched either from the command browser with scroll bar or from the snapshot window with time scroll bar). The graphical histories use a comic strip metaphor to depict graphical states changing over time. The two parts synchronize in changes so that the snapshot is always the execution result of the command at the top of the command list.

[2] Grouping commands: In graphical editing systems, we assume that a user usually decides what to do and remembers what had done from the state and attributes of graphical objects created and operated before. Therefore, when a user tries to perform an undo operation, he/she must have focused on the some particular object. Thus, presenting only the partial command history related with the object should be sufficient for the user to search and undo a command. This is the basic idea behind our history grouping facility. The user can browse and interact with the partial history of the selected object through the related commands that are selected by the search mechanism.

We also provide a mechanism based on the grouping of reusing objects and command to create a sophisticated scene.

3. EXPERIMENTS

To evaluate the tool we proposed, we design two experiments. On Experiment 1, we investigate user’s general satisfaction on the tool through a survey. On Experiment 2, we analyze user’s gaze information during a visual searching task, which models a typical task on the tool.

3.1. Experiment 1

We conducted a usability test to evaluate the visualization technique of use history proposed in this paper and administered a questionnaire to get subjective information on the participants satisfaction.

3.1.1. Interface Setup

We administered and compared three types of undo/redo interfaces:

(1) The combination of Command List and Snapshot (C&S-type),

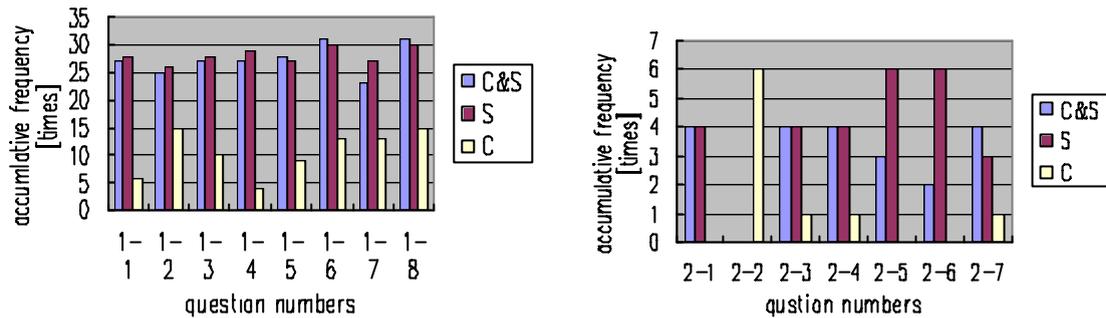


Figure 2. The results of questionnaire 1 (left), and questionnaire 2 (right)

- (2) Snapshot only (S-type), and
- (3) Command List only (C-type).

Before working on experimental tasks, participants practiced the graphical history tool use, including how to select an object, draw, and undo it.

3.1.2. Participants and Tasks

Six male college students (three undergraduates and three graduates) of our University Computer Science and Media Engineering participated in this experiment. They do not have any experience on our Undo/Redo system but are familiar with conventional Computer Graphics tools. Each participant worked on three types of tasks after becoming used to our Undo/Redo system.

A collaborative painting task by a participant and an instructor was adopted for this study. A participant paints pictures receiving instruction from him. During the drawing session, the instructor gives instructions, which require Undo/Redo operations, to the participant. To be precise, the task was conducted as follows.

- (1) Participant paints pictures.
- (2) Participant and instructor discuss the colors on pictures, and then she/he changes the color of designated graphical object.

3.1.3. Survey and Results

We administered a questionnaire for debriefing surveys (Table1). It consists of two parts. Part One of questions contains questions on the user acceptance of each interface type; participants were asked to rate the questions on 0-to-6 scales. Part Two of questions is for comparing usability items of the interface types; participants were asked to choose the best interface type out of the three on each item.

The results are shown in Figure 2. We found that accumulative frequency of C type is much less than that of C&S and S. However, there is not difference significantly between C&S and S type. We may need more experiments to evaluate difference between two C&S and S types.

3.2. Experiment 2

3.2.1. Experimental design

We then focused on snapshot and scroll bar. The aim of this experiment is to investigate user's eye movements when they are searching specific objects on the screen with the scroll bar in the history tool of a dialog box.

In order to attain this goal, we measured user's eye movements with an eye tracking equipment. We administered a prototype consisted of a snapshot and a scroll bar, it was written in Microsoft Visual Basic on Windows NT.

3.2.2. Participants and Equipment

Three students (two graduates and one undergraduate) of Computer Science and Media Engineering Department participated in the experiment. They all used to use Microsoft Windows 98 or NT, and are familiar with the scroll bar in the history tool in our experiment. To get reliable eye tracking data, all subjects were chosen so that they did not need eyeglasses or contact lenses.

The computer used in our experiment was a PC (IBM AT compatible PC), which consists of Pentium III 450MHz CPU and 128 Mb of memory. We used an 18-inch crystal liquid display and a tripod to fix the head position and viewing distance of a participant.

The eye tracker used was a head mounted equipment NAC EMR-8 model SP-505. This device illuminates infrared light through a mirror based on the principle of pupil and a corneal reflection. Gaze location and image pairs were superimposed on videotapes every 1/60 second.

3.2.3. Task

The task is to search the target snapshot looking at a window and operating scroll bar of the dialog box. A target snapshot consists of three circle objects with white or black colors (See Figure 3). The total number of target shots is eight. The size of each circle is 1.97 inches (5 centimeter) in diameter. The viewing distance is 17.5 inch. Participants need to move their eyes to search target objects under these conditions because the fovea of the eye is a small region with fine details (about 1 deg. of view angle)[Ware 87, Jacob 91].

Experimenter first gives an instruction (e.g., he says "right black, start") then a participant begins to search the target shot manipulating the scroll bar as quickly as possible. When the participant finds the target shot, he/she presses a button with their left hand to input the cue information. The cue information is recorded on tapes through an eye tracking equipment. A target shot and an order of eight snapshots are random. The experiment consists of 64 trials per participant. Each participant takes several rests during the experiment. Before restarting the experiment, we calibrate the eye tracker.

3.2.4. Analysis and Results

The initial analysis was made with NAC analysis software tool. Eye tracking data contain noisy data are excluded from the analysis. We have filtered noise data from eye track data. We also set up the temporal filter-determining fixation in filtering the noise in the data and analyzing values of the threshold of 120ms because the duration of a fixation is typically 120-600ms[Aaltonen 98]. We observed videotape images and investigated fixation data.

Figure 3 shows a typical pattern of search saccades with a target shot. Small circles (not at target circles) represent fixations, where the size of them shows duration of fixation. An observation was that user first looked at a region low right of a shot, then move around the center of a shot, and the eye remains there for a while.

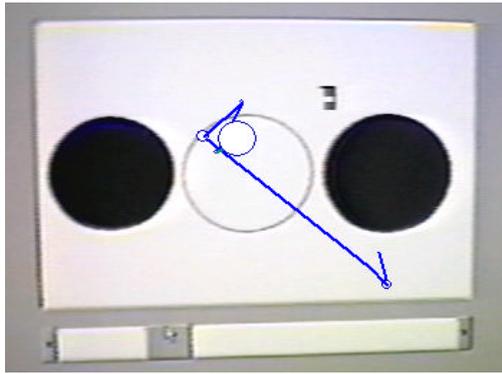


Figure 3. An example of eye movement overlapped with a target shot.

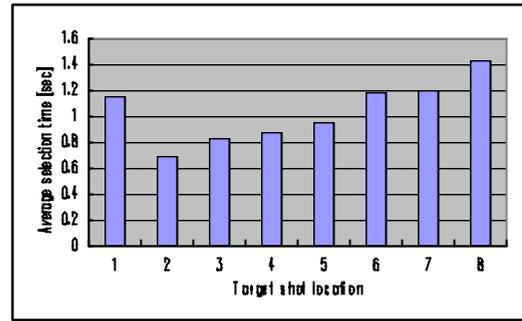


Figure 4. Target selection time by target shot.

The overall average duration time of fixation is 387 ms, and the average number of fixations is 2.2 times. The average selection time per trial is 1.04 sec. We calculate a ratio of the duration time of fixation for the selection time:

$$387(\text{ms} / \text{times}) * 2.2 (\text{times} / \text{trial}) = 851.4(\text{ms} / \text{trial}) \text{ and}$$

$$851.4(\text{ms} / \text{trial}) / 1004(\text{ms} / \text{trial}) \approx 0.848.$$

We found that user looked at the same point almost of time during the trial in Figure 3 and the ratio of the duration time calculated above. The ratio of duration 0.84 shows that the history tool with a snapshot and a scroll bar provides a function of fixing user's eye at the same position on the screen.

Figure 4 shows target selection time by target locations. An observation is that the target selection time is a function of the location except the first. The phenomenon can be seen previous menu selection study too [Byrne 99].

An observation that has been made in previous study [Velichkovsky 97] is that there are the relationship duration of fixation and 5 levels of human information processing. First level (fixation time is less than 100ms) is "saccades", second level (120-250ms) is categorized in Figurative processing, and third level (250-450ms) is categorized in Semantic processing. Our results of fixation time are categorized at the third level; in other words, the result shows that the task is semantic processing level.

Table 1. Contents of questions

Part One		
Question number	Questions	Selection items
1-1	It is easy to see the graphical representation of the history tool	+3 +2 +1 0 -1 -2 -3
1-2	The usage of history is right	+3 +2 +1 0 -1 -2 -3
1-3	The operation of the tool is successful	+3 +2 +1 0 -1 -2 -3
1-4	It is easy to find the target scene in history	+3 +2 +1 0 -1 -2 -3
1-5	The Visualization of the history tool is right.	+3 +2 +1 0 -1 -2 -3
1-6	The goal is attained.	+3 +2 +1 0 -1 -2 -3
1-7	Ease for history operation is right.	+3 +2 +1 0 -1 -2 -3
1-8	The tool should be needed in other applications.	+3 +2 +1 0 -1 -2 -3
Part Two		
2-1	It is easy to understand the resulted representation of operations.	C&S S C
2-2	There are many undo operations.	C&S S C
2-3	The goal is attained.	C&S S C
2-4	It is easy to operate the tool.	C&S S C
2-5	The operation of the tool is best matched to wish I think.	C&S S C

2-6	It is easy to use the tool.	C&S S C
2-7	The tool is useful.	C&S S C

4. SUMMARY AND FUTURE WORK

We present the object-based tool of visualizing and searching the history of graphical editing systems, and an empirical evaluation of the interface tool for a selective undo mechanism. The experiments produced a huge amount of data, and here we have only presented the first results. Our interesting questions require further experiments. These include the following:

- (1) Comparing the effectiveness of thumbnail representation of graphical history with the snapshot described in this paper.
- (2) Investigating the relationship in detail between mouse movements and eye movements under graphical history tool environment.

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REFERENCES

- [Aaltonen 98] A. Aaltonen, A. Hyrskykari, K. Raiha, 101 spots, or How do users read menus? *Proceedings of CHI98 Conference*, 1998, pp.132-139.
- [Berlage 94] T. Berlage, A Selective Undo Mechanism for Graphical User Interfaces Based on Command Objects, *ACM Transactions on Computer-Human Interaction*, Vol.1, No.3, 1994, pp.269-294.
- [Byrne 99] M. D. Byrne, J. R. Anderson, S. Douglass, M. Matessa, Eye Tracking the Visual Search of Click-Down Menus, *Proceedings of CHI99 Conference*, 1999, pp.402-409.
- [Jacob 91] R. J. K. Jacob, The use of eye movements in Human-Computer Interaction Techniques: What You Look At is What You Get, *ACM Transactions on Information Systems*, Vol.9, No.3, 1991, pp.152-169.
- [Meng 98] C. Meng, M. Yasue, A. Imamiya, X. Mao, Visualizing histories for selective Undo and Redo, *Proceedings of 3rd Asia Pacific Computer Human Interaction Conference*, Shonan Village Center, Japan, July 15-17, 1998, pp.459-464.
- [Myers 97] B. A. Myers, R. McDaniel, R. C. Miller, A. S. Ferrenco, A. D. Faulring, B. Kyle, A. Mickish, A. Klimovitski, P. Doane, The Amulet Environment: New models for Effective User Interface Software Development, *IEEE Transactions on Software Engineering*, Vol. 23, No. 6, 1997, pp.347-364.
- [Velichkovsky 97] B. Velichkovsky, A. Sprenger, P. Unema, Towards gaze-mediated interaction: Collecting solutions of the "Midas touch problem", *Human-Computer Interaction: INTERACT'97 (IFIP)*, Sydney, Australia, 1997, pp.509-516.
- [Ware 87] C. Ware, H. H. Mikaelian, An Evaluation of an Eye Tracker as a Device for Computer Input, *Proceedings of CHI + GI'87 Human Factors in Computing Systems Conference*, 1987, pp.183-188.
- [Zhou 97] C. Zhou and A. Imamiya, Object-based Non Linear Undo Model, *COMPSAC'97 (IFIP)*, Washington DC, USA, 1997, pp.50-55.